METHOD AND COMPOSITION FOR COMBATTING INSECTS AND VIRUSES TRANSMITTED TO PLANTS THEREBY

The present invention relates to a method and composition for combatting insects and insect-transmitted plant viruses by repelling insects from the plants.

It is a continuing objective of persons engaged in agriculture, to increase yields of crops such as vegetables, especially by combatting plant pests such as plant viruses introduced by insects. Use of insecticides by no means provides a complete answer to this problem, due to the known phenomenon of increasing insect resistance to insecticides.

An article by Smith, F.F. and Webb, R.E., entitled „Repelling Aphids by Reflective Surfaces ...“ at pages 631-639 of „Viruses, Vectors and Vegetation“ (Karl Maramorosch, ed.), Interscience Publishers, 1969, reviews earlier work describing the reaction aphids to different colors, and in particular the finding that aphids are attracted to yellow or modified yellow objects (such as a yellow pan), but are influenced also by the nature or color background of the background surrounding the yellow, e.g. unpainted aluminum pans surrounding yellow pans repels the aphids. The review also mentioned as a known fact, that sprayed foliage, especially that having a whitish residue, attracts aphids to land. The authors of this review then reported the results of their own experiments, in which it was found that foliage sprays of aluminum repelled as many aphids as aluminum sheets. The aluminum sprays, however, suffered from a number of disadvantages, namely, either the spray deposits adhered to plant for only 2-3 days and thereafter lost their effectiveness, or on rough hairy plants (such as cucumber, canteloupe or tobacco) the sprays left a dull gray deposit which did not repel aphids. More persistent aluminum sprays containing adhesive were found to stunt growth of foliage. Using aluminum sheets as mulches, in experiments with bush squashes, the authors found that maximum aphid repellency was obtained when 50% of the ground was thus covered, and that much higher yields were obtained than when using parathion spray, or in a control experiment. It was further reported

that aluminum sheet material was not succesful in repelling aphids from all plant species.

JP 04-190733A (published July, 1992) discloses a multi-film for repelling harmful insects and accelerating growth of vegetation, prepared from a composition containing thermoplastic resin, metal aluminium powder and mica, and optionally, e.g. antioxidants, and antistatic and UV absorbing agents. JP 04-152833A (published May, 1992) discloses a similar product for reducing the effect of harmful insects on agricultural products, but in which (in particular) the mica of the previous composition is replaced by mica that is TiO_2-coated as pearl pigment.

The entire disclosure of the literature reference and the Japanese patent publications mentioned above is explicitly incorporated herein by reference.

Thus, the tendency of the prior art known to the Applicant, so far as repelling insects by use of reflective materials is concerned, is to utilize sheet material which is either itself reflective as in the case of the aluminum sheet mulches described in the Smith and Webb articles, or which is apparently reflective by virtue of including reflective particles as in the case of the above-mentioned published Japanese patent applications.

However, these sheet materials suffer from two important disadvantages. Firstly, they tend to heat the microenvironment of the plants they are intended to protect, so that in warm climates the plants could be damaged or even destroyed by intense heat thus induced by these sheets. Secondly, these sheets are expensive, of the order of US $500 per 0.1 hectare.

Marco, S. in Phytopathology, 76: 1344-1348 (1986) reported the results of experiments in which potato crops were sprayed weekly with whitewashes. It was found that the potato leaf roll virus was reduced by 0-61% and the potato virus Y by 0-68%; and also that a number of aphid species were repelled by whitewash while one species was attracted (as determined by comparing the number of aphids attracted to sprayed traps and control

traps). However, the use of whitewashes suffers from serious disadvantages, namely: the repellent effect on insects is not powerful enough; increasing the concentration in the spray could harm the plants; and the sprayed crops would require special treatment to remove the whitewash from the fruit or vegetables in question. Whitewashes are in fact hardly used by farmers at all for crop protection, except for painting the bark of trees.

It has been surprisingly found in accordance with the present invention, that insects can be effectively repelled from growing plants in a manner which is considerably more economic than the prevalent method of using reflective mulching sheets, which avoids damage to or destruction of plants caused by use of such sheets in warm climates, and which avoids the above-noted disadvantage of whitewashes.

The present invention accordingly provides a method for protecting growing plants from insects and from insect-transmitted plant viruses, which comprises applying to a locus or loci selected from surfaces of growing plants and their background, a composition comprising reflective particles of at least one substance, provided that this is not solely uncoated aluminum, whereby said composition is effective to repel said insects and thus protect the plants.

In another aspect, the invention provides a composition for protecting growing plants from insects and from insect-transmitted plant viruses, which comprises reflective particles of at least one substance, together with at least one agriculturally acceptable diluent, carrier or adjuvant, provided that said substance is not solely uncoated aluminum.

The present invention provides a means for avoiding, at least to a large extent, the damaging effect on growing plants of destructive insects and insect-transmitted plant viruses. The method of the invention also reduces the temperature of the microenvironment of the plants, which can be of great importance in warm climates, e.g., leaf burns in zucchini are avoided, and the quality and sweetness of melons are improved. Additionally, the

method of the invention exhibits wavelength-dependent reflection of the infrared region.

The means of applying a composition comprising reflective particles to the surfaces of growing plants and/or their background in accordance with the invention may be done by any means known in the art. Spraying is presently preferred, but it does not exclude, e.g., the use of powders for dusting plants.

As will be apparent from the preceding paragraph, the compositions of the invention, which may be used in the method of the invention, are essentially admixtures which may take any form known per se in the art, e.g. they may be in the form of suspensions or dispersions for applying by means of a spray, or they may take the form of dusting powders. In any event, they may contain agriculturally acceptable conventional hydrophilic or lipophilic diluents, carriers or adjuvants. Examples for diluents are mineral oil, vegetable oil or water. For example, aqueous suspensions or dispersions may contain surface-active agents and/or adhesives for attaching the reflective particles to plants. Dusting powders may contain, e.g. solid carriers or diluents such as chalk or diatomaceous earth. The term „reflective particles“ is intended to include light-reflective powders, platelets, leaflets and laminae, and include light-reflective substances known for use in pigments as set forth in more detail infra.

As the reflective particles (or powders or platelets) which may be utilized in the practice of the method of the invention, there may be used, e.g., sheet silicates like talk, kaolin, sericit or mica, glass platelets, SiO_2 flakes, ceramic flakes, TiO_2 flakes, lithopones, platelet-shaped barium sulfate, platelet-shaped alumina or micaceous iron oxide, particularly when coated with one or more layers of earth metal carbonates, earth metal sulfates or metal oxides like TiO_2, Fe_2O_3, SnO, SiO_2, Al_2O_3, ZnO, ZrO and mixtures thereof. Coated mica platelets are for example marketed under the Registered Trade Marks „Iriodin“ (Merck KGaA, Darmstadt, Germany) and „Mearlin“ or „MagnaPearl“ (The Mearl Corporation, New York, U.S.A.), for use as pearl luster pigments. Especially preferred are mica platelets coated with TiO_2 and/or Fe_2O_3.

A particular non-limiting example of the Mearlin range of coated mica platelets, found to be useful in the present invention, is Mearlin Card Silver BN001, which contains generally 64-67 % mica, 22-31 % TiO_2, 2-4 % graphite („Graphitan 6154") and 0.1-0.5 % SnO_2; the usefulness of this product in the practice of the invention does not of course preclude the use of TiO_2-coated mica wherein the coating contains different amounts of graphite and SnO_2, of which contains only one or neither of these ingredients, or which contains other minor ingredients. A further example of the reflective particles, powders or platelets which may be utilized in the practice of the invention, is constituted by BiOCl crystals marketed under the Registered Trade Mark „Mearlite" (The Mearl Corporation).

As the reflective particles (or powders or platelets) which may be utilized in the practice of the invention, a further example consists of aluminum coated with epoxy and/or polyester, and marketed under the trade name „Debrex" by Debra Incorporated (New York, U.S.A.). Reflective copper or bronze particles, etc., are also potentially useful in practising the invention.

Further examples of the reflective particles, powders or platelets which may be utilized in the practice of the method of the invention, are constituted by pigment-free iridescent glitter also marketed by Debra Incorporated, such as (i) „HT glitter", (ii) „LR glitter" and (iii) „SR glitter". The essential polymers in these compositions appear to be: (i) polyethylene terephthalate + acrylates copolymer; (ii) polybutylene terephthalate + acrylates copolymer + ethylene/vinyl acetate copolymer; (iii) polyethylene terephthalate + polybutylene terephthalate + ethylene/vinyl acetate copolymer.

Additionally preferred are mixtures of reflective particles in combination with absorption pigments for example carbon black.

A person of the art will of course appreciate that in accordance with the invention, the active insect-repellent substances are selected for their light-reflective, pearlescent or glitter properties, and thus the actual chemical composition of the particles is a secondary consideration, except that since the present invention is principally concerned with treating crops intended

for human consumption it will of course be highly desirable that the active insect-repellent substances be non-toxic. A person of the art will also be aware that where such reflective particles, powders or platelets are supplied by the manufacturer in a vehicle for use as pigments, such vehicles could make these products unsuitable for agricultural applications, where predominantly aqueous vehicles would normally be used. In other words, the active insect-repellent substances should normally be initially in solvent-free form and will then be introduced for utilitarian purposes into an aqueous medium; this general principle does not of course exclude the possibility of utilizing such a commercially available substance in a vehicle suitable for agricultural application, provided that toxic substances are absent therefrom.

Without prejudice to the generality of the invention, it is presently believed that the method of the invention will be especially applicable to repelling aphids, leafhoppers, Lariomyza Bryoniae, white flies and thrips, from growing plants, thus protecting them from these insects as well as from plant viruses transmitted by these insects.

The invention will now be illustrated by the following examples.

Example 1

Six yellow plates (20 x 40 cm) were placed in a row at a distance of 15 meters from the edge of and along one side of a cotton field, and six such yellow plates were placed similarly in a second row, but at a distance of 25 meters from the edge of a field. The plates were sprayed (two from each row) with, respectively, 1% aqueous suspensions (containing 0.1% „Shatach 90" surface active agent) of mica coated with titanium dioxide (M.T.O.) and mica coated with titanium oxide and graphite (BN001 as described above), the plates having been sanded previously to improve distribution of the spray (which was not however distributed uniformly). Two control plates from each row were not sprayed. Each such spraying was followed by spraying with a transparent glue „Rimiput" for adhering leaf-hoppers landing on the plates. The experiment was commenced in the

evening of day 1 and the plates were collected in the afternoon of day 5, the number of leaf-hoppers on each plate being as follows:

Run No.	Control	M.T.O.	BN001
1	446	34	33
2	598	45	28
3	408	45	21
4	534	40	35
Mean	496.5	41	29.9
Standard Deviation	74.32	4.53	5.4

<ins>Summary of Results</ins>. M.T.O. and BN001 were, 91.73 and 94% effective, respectively, in reducing the no. of captured leaf-hoppers, compared with control, while the BN001 reduced the no. of captured leaf-hoppers by 28.56%, compared with M.T.O.

<ins>Example 2</ins>

Twenty yellow plates (20 x 20 cm) were placed at random in a melon field, and were sprayed in batches of five with, respectively, 1% aqueous suspensions (containing 0.1% „Shatach 90" surface active agent) of uncoated mica (M), mica coated with titanium oxide (M.T.O.) and mica coated with titanium oxide and graphite (BN001), the plates having been sanded previously to improve distribution of the spray (which was not however distributed uniformly). Five control plates were not sprayed. Each such spraying was followed by spraying with a transparent glue as in Example 1. After four days the number of white flies and leaf-hoppers on each plate was as follows:

(a) <ins>White flies:</ins> Effect of spraying on the number of white flies collected:

Run No.	Control	M	M.T.O.	BN001
1	432	368	344	124
2	469	421	132	321
3	500	370	217	256
4	493	437	203	280
5	535	375	278	132
Mean	485.8	394.2	234.8	176.4
Standard Deviation	34.2	28.95	71.68	108.89

Summary of Results. M.T.O. and BN001 were approximately 50-60% effective in reducing the incidence of captured white flies, whereas M also reduced the incidence of captured white flies but by <20%.

(b) Leaf hoppers: Effect of spraying on the number of leaf hoppers collected:

Run No.	Control	M	M.T.O.	BN001
1	39	97	6	5
2	69	48	5	10
3	55	28	3	2
4	92	83	15	2
5	77	43	3	5
Mean	66.4	56.8	6.4	4.8
Standard Deviation	18.19	25.9	4.5	2.9

Summary of Results. M.T.O. and BN001 were ≈90% effective in reducing the incidence of captured leaf-hoppers; M also showed a (non-statistical) tendency to reduce the incidence of captured leaf-hoppers.

Example 3

On July 25, 1991, Galia melon was sown in an experimental plot containing four rows, approximately seventy plants per row. The plants were divided into three groups: the control group was unsprayed, one group was sprayed with a commercial oil („Virol“) and the other group was sprayed according to the present invention (this spray was an aqueous suspension of 1% epoxy-coated aluminum particles, containing also (approximately) 0.1% surface-active agent and 0.1% polyvinyl agricultural adhesive). The sprayings were carried out after one leaf had formed (July 30), and again on August 4, 9, 15, 20, 25 and 30, and on September 11 and 16. The spray left only slight traces on the vegetation, which could be seen only with difficulty. Monitoring of Cucumber Mosaic Virus (CMV) (transmitted by aphids) was carried out on three dates prior to picking; monitoring of Cucumber Yellow Vein Clearing Virus (CYVV) (transmitted by white flies) was carried out only on the first date, since this virus had disappeared by the two later days. In each case monitoring was by observation, any doubtful cases being remitted for laboratory examination for serological confirmation of infection. The results of this experiment, in which each group for which data is given contained 62-75 plants, were as follows:

Percentages of infected plants in group

Date	Group	Control	„Virol“	Epoxy-coated A1
August 23 (CMV)	1	13.3	7.7	1.6
	2	10.0	12.5	4.4
	3	11.3	2.9	1.5
	4	7.7	7.4	1.4
	Mean	10.7	7.7	2.3
August 30 (CMV)	1	20.0	9.2	1.6
	2	12.9	18.1	4.4
	3	16.1	4.3	1.5
	4	7.7	7.4	1.4
	Mean	14.3	9.9	2.3

Sept. 16 (CMV)	1	20.0	9.2	1.6
	2	12.9	18.1	4.4
	3	16.1	10.1	4.6
	4	23.1	8.8	2.9
	Mean	18.0	11.7	3.4

Date	Group	Control	„Virol“	Epoxy-coated A1
August 23 (CYVV)	1	24.0	20.0	6.3
	2	21.4	5.6	1.5
	3	6.5	21.7	1.5
	4	7.7	2.9	10.1
	Mean	15.4	12.4	4.9

Conclusions. The above-tabulated results show that the rate of infection in the oil-treated plants was moderately lower than the control, while the plants sprayed in accordance with the invention showed a rate of infection considerably lower than the control.

Example 4

Plywood boar 50x50 cm was painted with a green shade with the same color as mature squash leaves. This color was selected to represent the attraction of insects to plants. Two additional controls were added: Yellow, that attracts many vector species (aphids, white flies, many leafhoppers etc.), and brown that represents poor attraction similar to that of bare ground. Green boards also served as background colors on which each of the pigments were applied. Five boards for each color were exposed on bare ground near a cotton field and some wild vegetation in the vicinity of Kibbutz Nachshon, in the internal central coastal plain ca. 30 km South of Tel Aviv and 40 km North West of Jerusalem. The boards were arranged randomly in the plot, at a distance of 7 m between each board. The pigments were applied to this board by spraying. On each board, once a week, were placed two A4 transparencies to which sticky tanglefoot were applied. These transparencies were removed for counting, and a new set was placed instead. Exposure was made on the 21st and 28th of August

and on the 4th, 11th, and 25th of September. The experimental design responds well for monitoring insects, based on the positive trappings on yellow and negative trappings on brown colors (see attached Table).

While particular embodiments of the invention have been described above, the skilled person will be aware that many variation and modifications may be made. The present invention includes all such variations and modifications which lie within the spirit, scope or concept of the present invention, and which would be apparent to the skilled addressee, on reading the present disclosure and the claims which follow.

Total captures of leafhoppers, thrips and white flies on 2 A4 transparency placed on 5 painted boards (10 in total). The counts represent exposure between August 21 and September 25 in Kibbutz Nachshon.

	Iriodin® 120	Iriodin® 221	Iriodin® 231	Iriodin® blue shade silver	Timiron® super blue	Iriodin® 235	Iriodin® 9612	Iriodin® 289	Iriodin® 9602	Iriodin® 163	Iriodin® 100	Iriodin® 299	G	Y	B
Leafh.	113	98	118	87	89	108	101	110	91	110	108	110	173	342	116
% of green	65.32	56.65	68.21	50.29	61.45	62.43	58.38	63.58	52.60	63.58	62.43	63.58	100.0	197.7	68.2
Thrips	386	572	926	321	273	447	415	506	615	523	468	979	1582	1159	383
% of green	24.4	36.2	58.5	20.3	17.3	28.3	26.2	32.0	38.9	33.1	29.6	61.9	100.0	73.3	24.2
White flies	1406	1704	1305	1786	2333	1190	2514	1505	1483	1695	1770	1366	3640	21997	1341
% f green	38.6	46.8	35.8	49.1	64.1	32.7	69.1	41.3	40.7	46.6	48.6	37.5	100.0	604.3	36.8

G = Green; Y = Yellow; B = Brown

Iriodin® 120: TiO_2 coated mica with a particle size of 5-20 µm (Merck KGaA, Darmstadt, Germany)
Iriodin® 221: TiO_2 coated mica with a particle size of 5-25 µm (Merck KGaA, Darmstadt, Germany)
Iriodin® 231: TiO_2 coated mica with a particle size of 5-25 µm (Merck KGaA, Darmstadt, Germany)
Iriodin® blue shade silver: TiO_2/Titan suboxides coated mica with a particle size of 10-40 µm, Merck KGaA, Darmstadt, Germany)
Timiron® super blue: TiO_2 coated mica with a particle size of 10-60 µm, Merck KGaA, Darmstadt, Germany)
Iriodin® 235: TiO_2 coated mica with a particle size of 10-60 µm, Merck KGaA, Darmstadt, Germany)
Iriodin® 9612: $FeTiO_3$ coated mica with a particle size of <15 µm (Merck KGaA, Darmstadt, Germany)
Iriodin® 289: TiO_2 coated mica with a particle size of 10-125 µm (Merck KGaA, Darmstadt, Germany)
Iriodin® 9602: $FeTiO_3$ coated mica with a particle size of 10-40 µm (Merck KGaA, Darmstadt, Germany)
Iriodin® 163: TiO_2 coated mica with a particle size of 20-180 µm (Merck KGaA, Darmstadt, Germany)
Iriodin® 100: TiO_2 coated mica with a particle size of 10-60 µm (Merck KGaA, Darmstadt, Germany)
Iriodin® 299: TiO_2 coated mica with a particle size of 10-125 µm (Merck KGaA, Darmstadt, Germany)